Credit Card Prediction

April 24, 2020

Objectives

Commercial banks receive a lot of applications for credit cards. Many of them get rejected for many reasons, like high loan balances, low income levels, or too many inquiries on an individual's credit report, for example. Manually analyzing these applications is mundane, error-prone, and time-consuming (and time is money!). Luckily, this task can be automated with the power of machine learning and pretty much every commercial bank does so nowadays

[3]:
```
import pandas as pd #Importing pandas
names =␣
↪['Gender','Age','Debt','Married','BankCustomer','EducationLevel','Ethnicity','YearsEmployed
#Loading the dataset taken from UCI ML data repository into the dataFrame named␣
↪cc_apps.
#Since the dataset has no headers, we set header = None to specify pandas that␣
↪the dataset has no header.
cc_apps = pd.read_csv("crx.data", names= names)

cc_apps.head(5)
#Since it's a sensitive dataset, The Values in the dataset have been changed to␣
↪meaniningless characters.
#We don't need original values as such to classify though.
```

[3]:
```
  Gender    Age   Debt Married BankCustomer EducationLevel Ethnicity  \
0      b  30.83  0.000       u            g              w         v
1      a  58.67  4.460       u            g              q         h
2      a  24.50  0.500       u            g              q         h
3      b  27.83  1.540       u            g              w         v
4      b  20.17  5.625       u            g              w         v

   YearsEmployed PriorDefault Employed  CreditScore DriversLicense Citizen  \
0           1.25            t        t            1              f       g
1           3.04            t        t            6              f       g
2           1.50            t        f            0              f       g
3           3.75            t        t            5              t       g
4           1.71            t        f            0              f       s

  ZipCode  Income ApprovalStatus
0   00202       0              +
```

```
1   00043    560              +
2   00280    824              +
3   00100      3              +
4   00120      0              +
```

The probable features in a typical credit card application are -

Gender

Age

Debt

Married

BankCustomer

EducationLevel

Ethnicity

YearsEmployed

PriorDefault

Employed

CreditScore

DriversLicense

Citizen

ZipCode

Income

ApprovalStatus

[4]:
```
cc_apps_description = cc_apps.describe()
print(cc_apps_description)

print("\n")

# Print DataFrame information
cc_apps_info = cc_apps.info()
print(cc_apps_info)

print("\n")
```

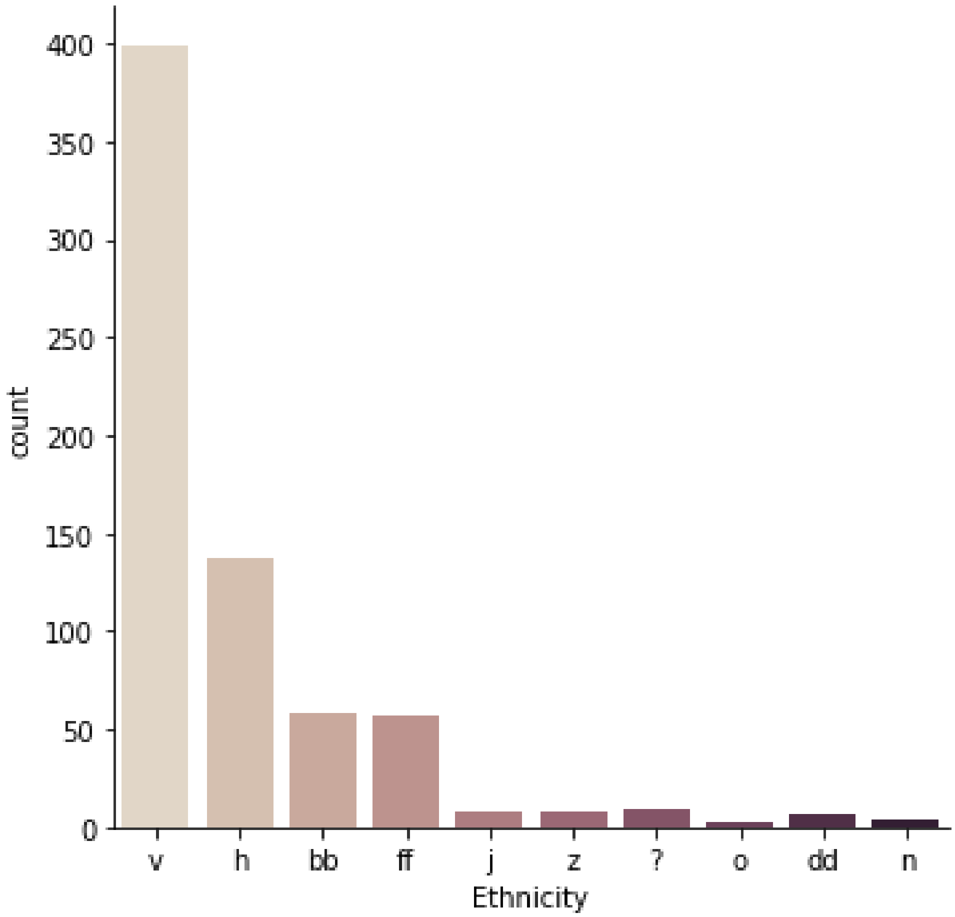
```
             Debt  YearsEmployed  CreditScore         Income
count  690.000000     690.000000    690.00000     690.000000
mean     4.758725       2.223406      2.40000    1017.385507
std      4.978163       3.346513      4.86294    5210.102598
min      0.000000       0.000000      0.00000       0.000000
25%      1.000000       0.165000      0.00000       0.000000
```

```
50%      2.750000       1.000000       0.00000       5.000000
75%      7.207500       2.625000       3.00000     395.500000
max     28.000000      28.500000      67.00000  100000.000000
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 690 entries, 0 to 689
Data columns (total 16 columns):
Gender            690 non-null object
Age               690 non-null object
Debt              690 non-null float64
Married           690 non-null object
BankCustomer      690 non-null object
EducationLevel    690 non-null object
Ethnicity         690 non-null object
YearsEmployed     690 non-null float64
PriorDefault      690 non-null object
Employed          690 non-null object
CreditScore       690 non-null int64
DriversLicense    690 non-null object
Citizen           690 non-null object
ZipCode           690 non-null object
Income            690 non-null int64
ApprovalStatus    690 non-null object
dtypes: float64(2), int64(2), object(12)
memory usage: 86.4+ KB
None
```

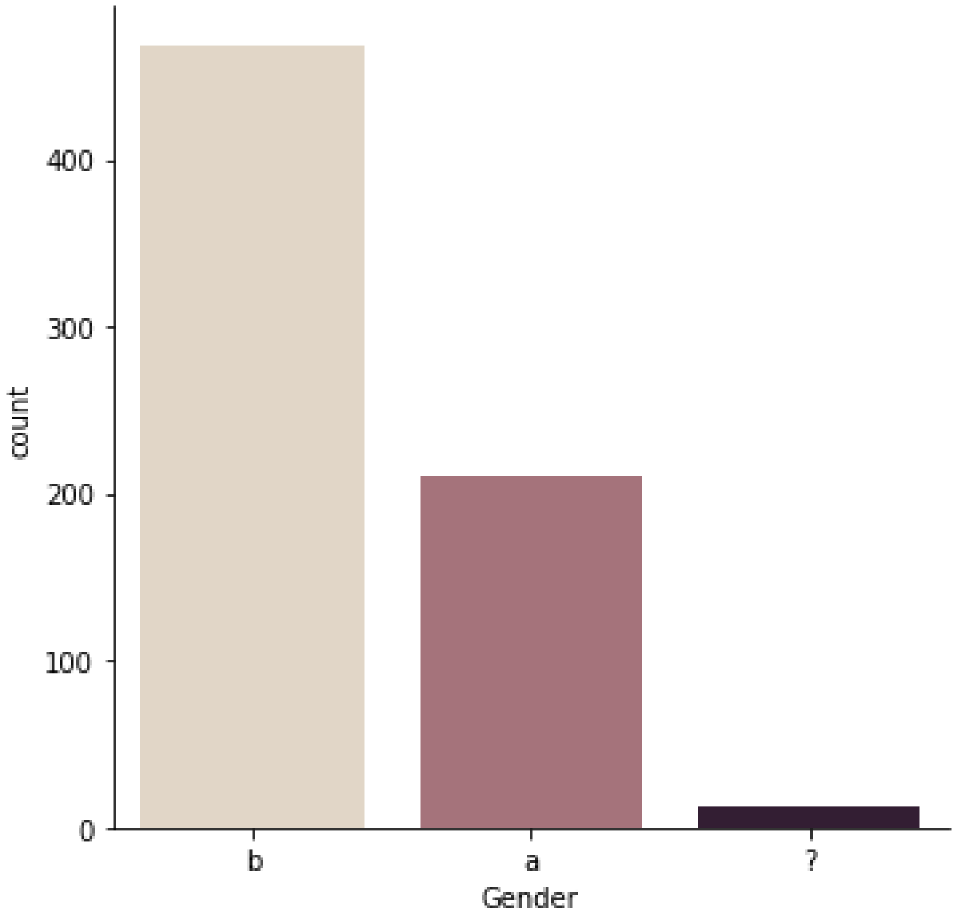
[5]:
```
import matplotlib.pyplot as plt
import seaborn as sns
sns.catplot(x = 'Ethnicity', kind = "count", palette = "ch: 0.25", data =␣
 ↪cc_apps)
#We can see that different types of ethnic people that apply. This class is␣
 ↪ruled by "v"
```

[5]: <seaborn.axisgrid.FacetGrid at 0x198f5c27f60>



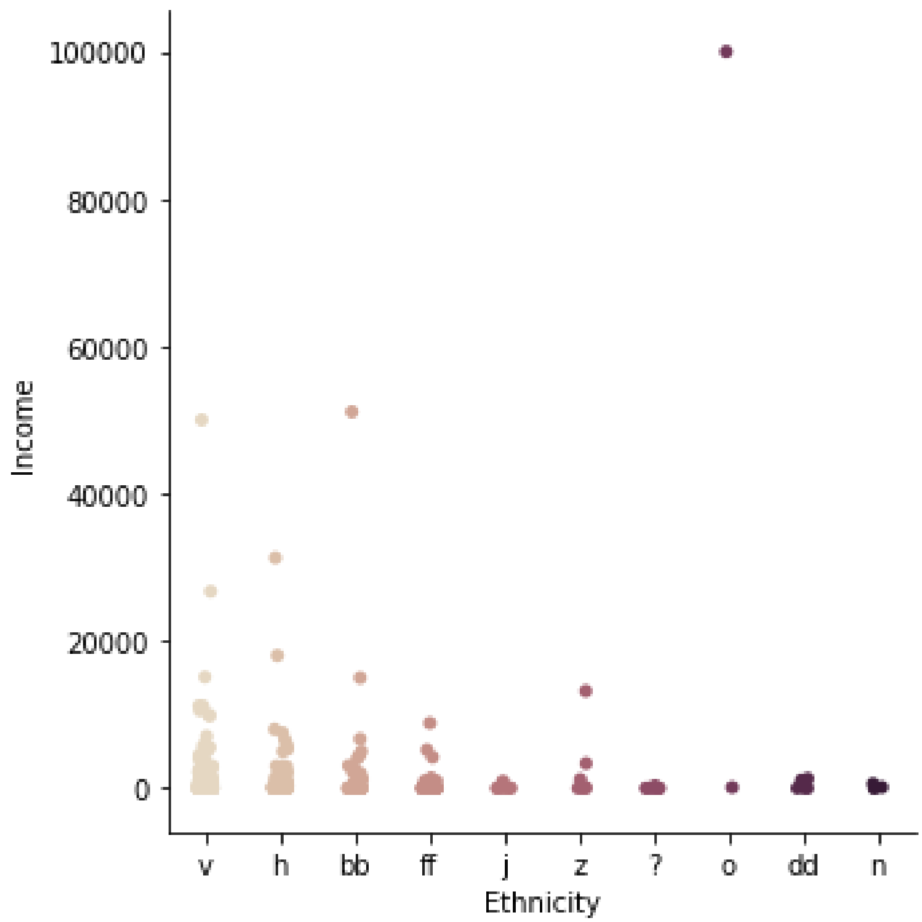
[6]:
```
sns.catplot(x = 'Gender', kind = "count", palette = "ch: 0.25", data = cc_apps)
#different genders that apply. b is probabaly male and a is female.
```

[6]: <seaborn.axisgrid.FacetGrid at 0x198f8257390>



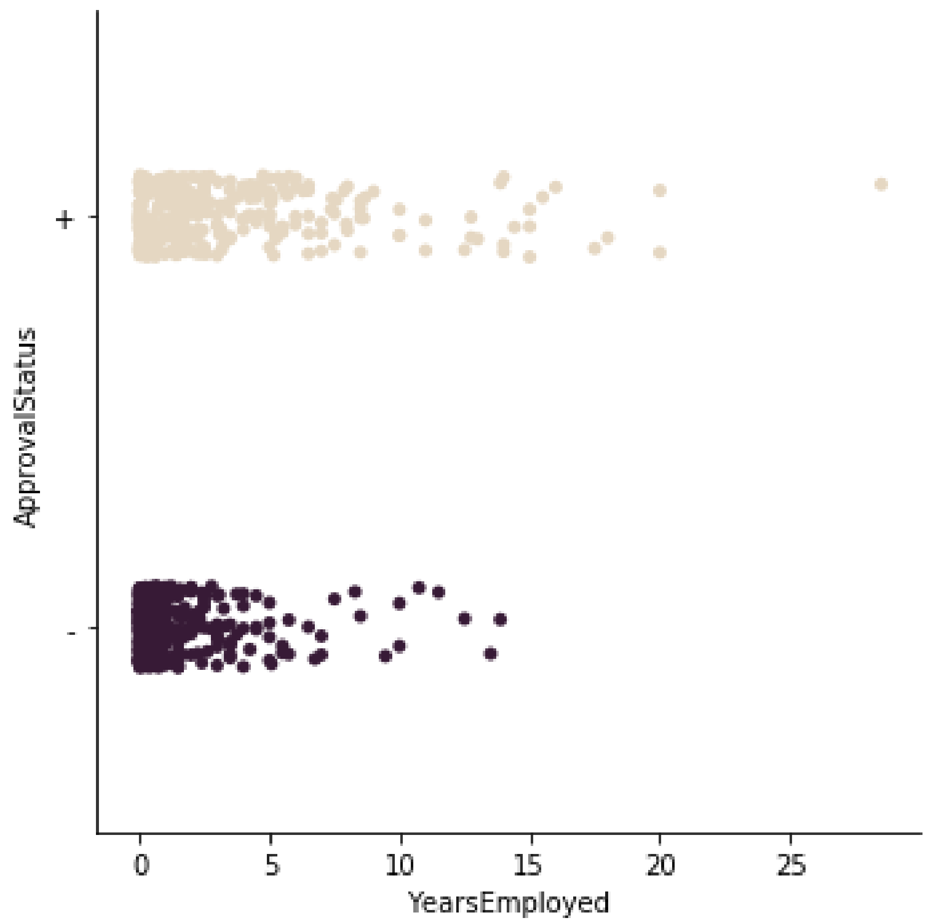
[7]:
```
sns.catplot(x = 'Ethnicity',y = 'Income', palette = "ch: 0.25", data = cc_apps)
```

[7]: <seaborn.axisgrid.FacetGrid at 0x198f828e2e8>



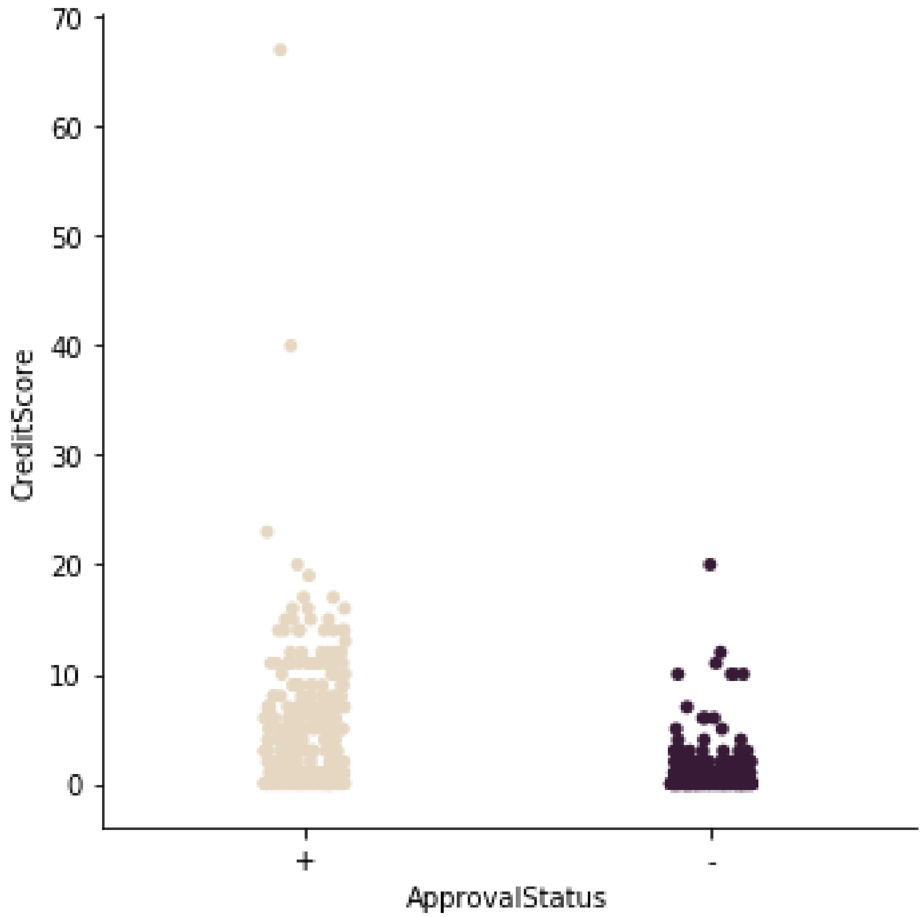
[11]:
```
sns.catplot(x = 'YearsEmployed', y = 'ApprovalStatus', palette = "ch: 0.25",␣
↪data = cc_apps)
```

[11]: <seaborn.axisgrid.FacetGrid at 0x198f5ad2630>



[14]:
```
sns.catplot(x = 'ApprovalStatus',y = 'CreditScore', palette = "ch: 0.25", data␣
↪= cc_apps)
```

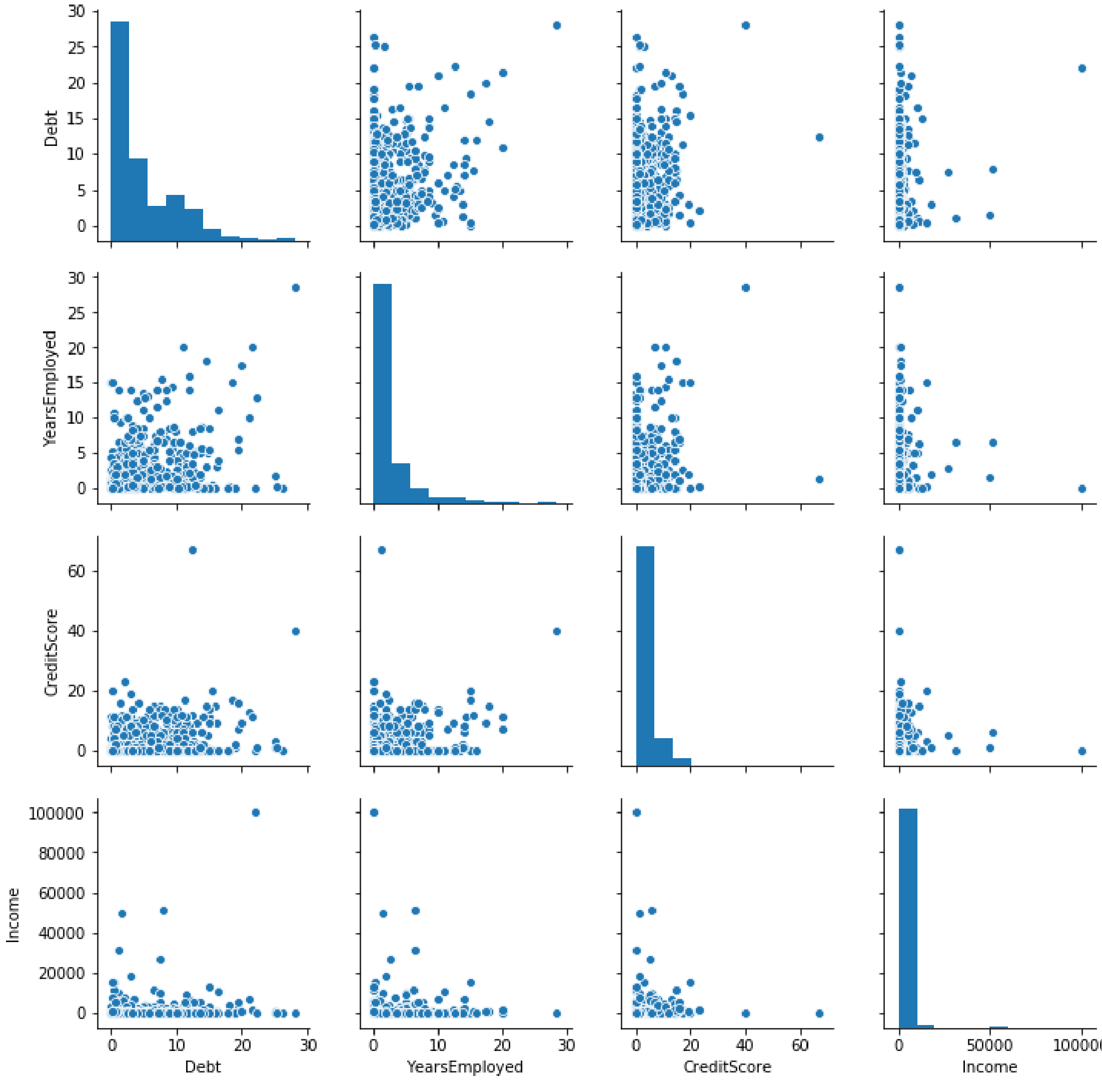
[14]: <seaborn.axisgrid.FacetGrid at 0x198f837a908>



[ ]:

[12]:
```
sns.pairplot(cc_apps)
```

[12]: <seaborn.axisgrid.PairGrid at 0x1d1459ef668>



Handling Missing Values

Our dataset contains both numeric and non-numeric data (specifically data that are of float64, int64 and object types). Specifically, the features 2, 7, 10 and 14 contain numeric values (of types float64, float64, int64 and int64 respectively) and all the other features contain non-numeric values.

The missing values in the dataset are labeled with '?', which can be seen in the last cell's output.

Let's replace the ? by Nan for ease of computation.

[ ]:

```
```

[13]:

```
# Import numpy
# ... YOUR CODE FOR TASK 3 ...
import numpy as np
# Inspect missing values in the dataset
```

```python
print(cc_apps.tail(17))

# Replace the '?'s with NaN
cc_apps = cc_apps.replace(['?'], np.NaN)

# Inspect the missing values again
print(cc_apps.tail(17))
# ... YOUR CODE FOR TASK 3 ...
```

```
    Gender    Age    Debt Married BankCustomer EducationLevel Ethnicity  \
673      ?  29.50   2.000       y            p              e         h
674      a  37.33   2.500       u            g              i         h
675      a  41.58   1.040       u            g             aa         v
676      a  30.58  10.665       u            g              q         h
677      b  19.42   7.250       u            g              m         v
678      a  17.92  10.210       u            g             ff        ff
679      a  20.08   1.250       u            g              c         v
680      b  19.50   0.290       u            g              k         v
681      b  27.83   1.000       y            p              d         h
682      b  17.08   3.290       u            g              i         v
683      b  36.42   0.750       y            p              d         v
684      b  40.58   3.290       u            g              m         v
685      b  21.08  10.085       y            p              e         h
686      a  22.67   0.750       u            g              c         v
687      a  25.25  13.500       y            p             ff        ff
688      b  17.92   0.205       u            g             aa         v
689      b  35.00   3.375       u            g              c         h

     YearsEmployed PriorDefault Employed  CreditScore DriversLicense Citizen  \
673          2.000            f        f            0              f       g
674          0.210            f        f            0              f       g
675          0.665            f        f            0              f       g
676          0.085            f        t           12              t       g
677          0.040            f        t            1              f       g
678          0.000            f        f            0              f       g
679          0.000            f        f            0              f       g
680          0.290            f        f            0              f       g
681          3.000            f        f            0              f       g
682          0.335            f        f            0              t       g
683          0.585            f        f            0              f       g
684          3.500            f        f            0              t       s
685          1.250            f        f            0              f       g
686          2.000            f        t            2              t       g
687          2.000            f        t            1              t       g
688          0.040            f        f            0              f       g
689          8.290            f        f            0              t       g
```

	ZipCode	Income	ApprovalStatus
673	00256	17	-
674	00260	246	-
675	00240	237	-
676	00129	3	-
677	00100	1	-
678	00000	50	-
679	00000	0	-
680	00280	364	-
681	00176	537	-
682	00140	2	-
683	00240	3	-
684	00400	0	-
685	00260	0	-
686	00200	394	-
687	00200	1	-
688	00280	750	-
689	00000	0	-

	Gender	Age	Debt	Married	BankCustomer	EducationLevel	Ethnicity	\
673	NaN	29.50	2.000	y	p	e	h	
674	a	37.33	2.500	u	g	i	h	
675	a	41.58	1.040	u	g	aa	v	
676	a	30.58	10.665	u	g	q	h	
677	b	19.42	7.250	u	g	m	v	
678	a	17.92	10.210	u	g	ff	ff	
679	a	20.08	1.250	u	g	c	v	
680	b	19.50	0.290	u	g	k	v	
681	b	27.83	1.000	y	p	d	h	
682	b	17.08	3.290	u	g	i	v	
683	b	36.42	0.750	y	p	d	v	
684	b	40.58	3.290	u	g	m	v	
685	b	21.08	10.085	y	p	e	h	
686	a	22.67	0.750	u	g	c	v	
687	a	25.25	13.500	y	p	ff	ff	
688	b	17.92	0.205	u	g	aa	v	
689	b	35.00	3.375	u	g	c	h	

	YearsEmployed	PriorDefault	Employed	CreditScore	DriversLicense	Citizen	\
673	2.000	f	f	0	f	g	
674	0.210	f	f	0	f	g	
675	0.665	f	f	0	f	g	
676	0.085	f	t	12	t	g	
677	0.040	f	t	1	f	g	
678	0.000	f	f	0	f	g	
679	0.000	f	f	0	f	g	
680	0.290	f	f	0	f	g	
681	3.000	f	f	0	f	g	
682	0.335	f	f	0	t	g	

```
683          0.585           f        f          0           f       g
684          3.500           f        f          0           t       s
685          1.250           f        f          0           f       g
686          2.000           f        t          2           t       g
687          2.000           f        t          1           t       g
688          0.040           f        f          0           f       g
689          8.290           f        f          0           t       g

    ZipCode  Income ApprovalStatus
673   00256      17              -
674   00260     246              -
675   00240     237              -
676   00129       3              -
677   00100       1              -
678   00000      50              -
679   00000       0              -
680   00280     364              -
681   00176     537              -
682   00140       2              -
683   00240       3              -
684   00400       0              -
685   00260       0              -
686   00200     394              -
687   00200       1              -
688   00280     750              -
689   00000       0              -
```

We will replace the Nan values with the mean of that particular column.

[14]:
```python
# Impute the missing values with mean imputation
cc_apps.fillna(cc_apps.mean(), inplace=True)

# Count the number of NaNs in the dataset to verify
pd.isna(cc_apps)
cc_apps.tail()
```

[14]:
```
    Gender    Age    Debt Married BankCustomer EducationLevel Ethnicity  \
685      b  21.08  10.085       y            p              e         h
686      a  22.67   0.750       u            g              c         v
687      a  25.25  13.500       y            p             ff        ff
688      b  17.92   0.205       u            g             aa         v
689      b  35.00   3.375       u            g              c         h

     YearsEmployed PriorDefault Employed  CreditScore DriversLicense Citizen  \
685           1.25            f        f            0              f       g
686           2.00            f        t            2              t       g
687           2.00            f        t            1              t       g
688           0.04            f        f            0              f       g
```

```
689           8.29          f       f           0             t       g

    ZipCode  Income ApprovalStatus
685   00260       0              -
686   00200     394              -
687   00200       1              -
688   00280     750              -
689   00000       0              -
```

[15]:

```
# Iterate over each column of cc_apps
for col in cc_apps:
    # Check if the column is of object type
    if cc_apps[col].dtype == 'object':
        # Impute with the most frequent value
        cc_apps = cc_apps.fillna(cc_apps[col].value_counts().index[0])

# Count the number of NaNs in the dataset and print the counts to verify
print(cc_apps.count())
cc_apps.tail(20)
```

```
Gender            690
Age               690
Debt              690
Married           690
BankCustomer      690
EducationLevel    690
Ethnicity         690
YearsEmployed     690
PriorDefault      690
Employed          690
CreditScore       690
DriversLicense    690
Citizen           690
ZipCode           690
Income            690
ApprovalStatus    690
dtype: int64
```

[15]:

```
    Gender    Age    Debt Married BankCustomer EducationLevel Ethnicity  \
670      b  47.17   5.835       u            g              w         v
671      b  25.83  12.835       u            g             cc         v
672      a  50.25   0.835       u            g             aa         v
673      b  29.50   2.000       y            p              e         h
674      a  37.33   2.500       u            g              i         h
675      a  41.58   1.040       u            g             aa         v
676      a  30.58  10.665       u            g              q         h
677      b  19.42   7.250       u            g              m         v
```

678	a	17.92	10.210	u	g	ff	ff
679	a	20.08	1.250	u	g	c	v
680	b	19.50	0.290	u	g	k	v
681	b	27.83	1.000	y	p	d	h
682	b	17.08	3.290	u	g	i	v
683	b	36.42	0.750	y	p	d	v
684	b	40.58	3.290	u	g	m	v
685	b	21.08	10.085	y	p	e	h
686	a	22.67	0.750	u	g	c	v
687	a	25.25	13.500	y	p	ff	ff
688	b	17.92	0.205	u	g	aa	v
689	b	35.00	3.375	u	g	c	h

	YearsEmployed	PriorDefault	Employed	CreditScore	DriversLicense	Citizen \
670	5.500	f	f	0	f	g
671	0.500	f	f	0	f	g
672	0.500	f	f	0	t	g
673	2.000	f	f	0	f	g
674	0.210	f	f	0	f	g
675	0.665	f	f	0	f	g
676	0.085	f	t	12	t	g
677	0.040	f	t	1	f	g
678	0.000	f	f	0	f	g
679	0.000	f	f	0	f	g
680	0.290	f	f	0	f	g
681	3.000	f	f	0	f	g
682	0.335	f	f	0	t	g
683	0.585	f	f	0	f	g
684	3.500	f	f	0	t	s
685	1.250	f	f	0	f	g
686	2.000	f	t	2	t	g
687	2.000	f	t	1	t	g
688	0.040	f	f	0	f	g
689	8.290	f	f	0	t	g

	ZipCode	Income	ApprovalStatus
670	00465	150	-
671	00000	2	-
672	00240	117	-
673	00256	17	-
674	00260	246	-
675	00240	237	-
676	00129	3	-
677	00100	1	-
678	00000	50	-
679	00000	0	-
680	00280	364	-

```
681    00176    537            -
682    00140      2            -
683    00240      3            -
684    00400      0            -
685    00260      0            -
686    00200    394            -
687    00200      1            -
688    00280    750            -
689    00000      0            -
```

[16]:

```
# Import LabelEncoder
from sklearn.preprocessing import LabelEncoder
# ... YOUR CODE FOR TASK 6 ...

# Instantiate LabelEncoder
le = LabelEncoder()
# ... YOUR CODE FOR TASK 6 ...

# Iterate over all the values of each column and extract their dtypes
for col in cc_apps:
    # Compare if the dtype is object
    if cc_apps[col].dtype=='object':
    # Use LabelEncoder to do the numeric transformation
        cc_apps[col]=le.fit_transform(cc_apps[col])
cc_apps.head()
```

[16]:

```
   Gender  Age   Debt  Married  BankCustomer  EducationLevel  Ethnicity  \
0       1  156  0.000        2             1              13          8
1       0  328  4.460        2             1              11          4
2       0   89  0.500        2             1              11          4
3       1  125  1.540        2             1              13          8
4       1   43  5.625        2             1              13          8

   YearsEmployed  PriorDefault  Employed  CreditScore  DriversLicense  \
0           1.25             1         1            1               0
1           3.04             1         1            6               0
2           1.50             1         0            0               0
3           3.75             1         1            5               1
4           1.71             1         0            0               0

   Citizen  ZipCode  Income  ApprovalStatus
0        0       68       0               0
1        0       11     560               0
2        0       96     824               0
3        0       31       3               0
4        2       37       0               0
```

[18]:
```
# Import train_test_split
from sklearn.model_selection import train_test_split
# ... YOUR CODE FOR TASK 7 ...

# Drop the features 11 and 13 and convert the DataFrame to a NumPy array
cc_apps = cc_apps.drop(['DriversLicense', 'ZipCode'], axis=1)
cc_apps = cc_apps.values

# Segregate features and labels into separate variables
X,y = cc_apps[:,0:13] , cc_apps[:,13]

# Split into train and test sets
X_train, X_test, y_train, y_test = train_test_split(X,
                                y,
                                test_size=0.2,
                                random_state=42)
```

[19]:
```
# Import MinMaxScaler
from sklearn.preprocessing import MinMaxScaler
# ... YOUR CODE FOR TASK 8 ...

# Instantiate MinMaxScaler and use it to rescale X_train and X_test
scaler = MinMaxScaler(feature_range=(0, 1))
rescaledX_train = scaler.fit_transform(X_train)
rescaledX_test = scaler.fit_transform(X_test)
```

[20]:
```
# Instantiate a LogisticRegression classifier with default parameter values
from sklearn.linear_model import LogisticRegression
logreg = LogisticRegression()

# Fit logreg to the train set
logreg.fit(X_train,y_train)
```

```
C:\ProgramData\Anaconda3\lib\site-
packages\sklearn\linear_model\_logistic.py:940: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

[20]:
```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
```

```
                    multi_class='auto', n_jobs=None, penalty='l2',
                    random_state=None, solver='lbfgs', tol=0.0001, verbose=0,
                    warm_start=False)
```

[ ]:

[21]:
```python
from sklearn.metrics import confusion_matrix
y_pred = logreg.predict(X_test)

# Get the accuracy score of logreg model and print it
print("Accuracy of logistic regression classifier: ",logreg.
 ↪score(X_test,y_test))

# Print the confusion matrix of the logreg model

print(confusion_matrix(y_test,y_pred))
```

```
Accuracy of logistic regression classifier:  0.7898550724637681
[[51 19]
 [10 58]]
```

[22]:
```python
from sklearn.model_selection import GridSearchCV
# Define the grid of values for tol and max_iter
tol = [0.01,0.001,0.0001]
max_iter = [100,150,200]

# Create a dictionary where tol and max_iter are keys and the lists of their␣
 ↪values are corresponding values
param_grid = dict(tol=tol, max_iter=max_iter)
```

[23]:
```python
# Instantiate GridSearchCV with the required parameters
grid_model = GridSearchCV(estimator=logreg, param_grid=param_grid, cv=5)

# Fit data to grid_model
grid_model_result = grid_model.fit(X, y)

# Summarize results
best_score, best_params = grid_model_result.best_score_,grid_model_result.
 ↪best_params_
print("Best: %f using %s" % (best_score, best_params))
```

```
C:\ProgramData\Anaconda3\lib\site-
packages\sklearn\linear_model\_logistic.py:940: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
```

```
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
C:\ProgramData\Anaconda3\lib\site-
packages\sklearn\linear_model\_logistic.py:940: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
C:\ProgramData\Anaconda3\lib\site-
packages\sklearn\linear_model\_logistic.py:940: ConvergenceWarning: lbfgs failed
to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-
regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
C:\ProgramData\Anaconda3\lib\site-
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```

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Best: 0.836232 using {'max_iter': 150, 'tol': 0.01}
```

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[ ]:

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